Response of Average Electron Velocity Vector under AC Electric and DC Magnetic Fields in a Constant-Collision-Frequency Model

HIROTAKE SUGAWARA, Hokkaido University, Japan — In order to study fundamental features of electron transport in magnetized plasmas, the average electron velocity $\mathbf{V}$ in gas under uniform AC electric and DC magnetic fields, $\mathbf{E}$ and $\mathbf{B}$, crossed at a right angle is theoretically derived assuming a constant collision frequency $\nu$. When $\mathbf{E} = (0, -E \sin \omega_E t, 0)$ and $\mathbf{B} = (0, 0, B)$, the analytical solution of $\mathbf{V} = (V_x, V_y, V_z)$ in periodical steady state is

\[ V_x = 2a \left[ \omega_E^2 \cos \omega_E t + \nu^2 \right] \sin \omega_E t, \]
\[ V_y = \left[ a (\omega_E^2 + \omega_B^2 + \nu^2) \right] \sin \omega_E t - \left[ a (\omega_E^2 - \omega_B^2 + \nu^2) \right] \cos \omega_E t \]
\[ V_z = 0. \]

Here, $a = eE/m$, $\omega_B = eB/m$, $\Omega = (\omega_E^2 + \omega_B^2 + \nu^2)/(\omega_E^2 - \omega_B^2 + \nu^2)$, and $e$ and $m$ are the electronic charge and mass. Although this model ignores the dependence of the collisions on electron energy, it is a merit that basic $\mathbf{V}$ responses at various $E$ and $B$ are predictable from the solution. $\mathbf{V}$ draws an ellipse in the $V_xV_y$-plane synchronously to $\mathbf{E}$ and the tilt of its major axis represents the time-averaged Hall deflection angle of $\mathbf{V}$. This depiction is informative to understand the electron swarm response under AC $\mathbf{E}$ and DC $\mathbf{B}$ fields.

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